

Subject Area:

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Kay annuloplasty of the tricuspid valve versus ring annuloplasty for repair of functional tricuspid regurgitation

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Abstract

Objective

Ideal management of functional tricuspid regurgitation (TR) has been a matter of debate for a long time. We try to discuss the midterm results with tricuspid Kay annuloplasty versus ring tricuspid annuloplasty for the treatment of functional TR.

Patients and methods

From January 2015 to January 2019, 82 patients underwent tricuspid annuloplasty for functional TR as part of their cardiac surgical procedure. Kay annuloplasty was performed in 55 patients and ring annuloplasty in 27 patients. Preoperatively, patients had moderate or greater TR with a median regurgitation of +3. Follow-up information was obtained for the patients with a mean follow-up time of 3 years. Postoperative transthoracic echocardiograms were assessed for severity of TR. Moderate or greater TR was considered significant. Survival and development of recurrent TR were evaluated by transthoracic echocardiograms analysis. TR and risk factors for recurrent regurgitation were identified and analyzed.

Results

At 3 years postoperatively, TR in patients treated by Kay annuloplasty was zero to mild in 75%, moderate in 11%, moderate to severe in 6%, and severe in 8% of patients. In those undergoing ring annuloplasty, TR was zero to mild in 69%, moderate in 14%, moderate to severe in 7%, and severe in 10%. There was no significant difference between the two groups. Risk factors for recurrent TR included higher preoperative regurgitation grade, preoperative TR without concomitant mitral regurgitation, and higher pulmonary artery systolic pressure.

Conclusion

Kay annuloplasty and ring annuloplasty were effective in eliminating TR at 3 years postoperatively. Kay annuloplasty is a simple, inexpensive option for addressing functional TR. All patients with moderate-to-severe functional TR should undergo tricuspid annuloplasty regardless of the technique used.

Keywords: Kay annuloplasty, ring repair for tricuspid valve, tricuspid valve repair

Body

Repair of functional tricuspid regurgitation (TR) is a challenging problem.

With relatively few definitive clinical studies to guide management decisions, cardiac surgeons still debate when and how to repair the tricuspid valve. Early investigators advocated a conservative approach, arguing that functional TR, often secondary to pulmonary hypertension and concomitant mitral valve disease, should spontaneously improve after mitral valve repair [1]. Subsequent studies, however, have

demonstrated that TR does not necessarily regress after repair of left-sided valve lesions [2–7]. Uncorrected TR increases both postoperative morbidity and mortality and is associated with poor long-term results with medical management alone [8,9]. Thus, many cardiac surgeons advocate tricuspid annuloplasty at the time of mitral valve surgery in patients with moderate or severe TR [10,11]. Several annuloplasty methods

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have been described; however, few studies have evaluated and compared the efficacy and durability of these techniques [12].

Kay annuloplasty was originally described by Kay *et al.* [13] as a technique to correct TR. This relatively simple technique involved figure-of-eight suture plication of the posterior leaflet to reduce annulus size. Kay annuloplasty, however, has since been superseded by other techniques seeking to remodel the annulus by maintaining a trileaflet valve with a more physiologic, stabilized annulus. These techniques include de Vega's semicircular annuloplasty [14] and the use of prosthetic annuloplasty rings, such as the Carpentier–Edwards semirigid ring (Edwards Lifesciences, Irvine, California, USA) [10], the Cosgrove–Edwards flexible band (Edwards Lifesciences) [15], and the Duran flexible ring [16]. A small number of studies comparing ring annuloplasty with suture annuloplasties (primarily the de Vega) have concluded that ring annuloplasty offers a more durable repair and that ring annuloplasty should support suture annuloplasty for the repair of functional TR [12,17–19]. Other investigators have reported good experience with the de Vega annuloplasty and continue to advocate its use [20,21].

At our institution, we routinely perform a modified suture Kay annuloplasty of the tricuspid valve or a ring annuloplasty in all patients with moderate-to-severe functional TR who present for cardiac surgery. Since the dilation of the tricuspid valve primarily occurs at the posterior leaflet, posterior Kay annuloplasty offers an inexpensive, simple, and rapid repair. Kay annuloplasty may have a role, particularly, in cases of moderate TR, where a simple repair may be all that is required. The option to perform a simple repair without significantly prolonging operative time or requiring a prosthetic ring is appealing. In this study, we review and compare our experience with kay bicuspidization and ring annuloplasty for the repair of functional TR to determine the efficacy and durability of tricuspid annuloplasty.

Aim

We sought to address the following points:

- (1) What is the efficacy and durability of tricuspid annuloplasty with Kay and ring annuloplasty over the midterm postoperative period?
- (2) How does Kay annuloplasty compare with ring annuloplasty?
- (3) What is the functional improvement after tricuspid valve repair?
- (4) What are the risk factors for repair failure?

PATIENTS AND METHODS

Patients

Ethical committee approval was taken and patient's consent was taken from January 2015 to December 2019, 82 patients underwent tricuspid annuloplasty for functional TR as part of their cardiac surgical procedure at the National Heart Institute of Egypt. Patients were identified and preoperative, operative, and postoperative variables were retrieved from the patient database.

Kay annuloplasty was performed in 55 (67.1%) patients.

Ring annuloplasty was performed in 27 (32.9%) patients.

Patient preoperative and surgical characteristics are given in Table 1.

The mean age of the patients was 52 ± 14 years and 52 (63.5%) of the patients were women and 30 (36.5%) of the patients were men.

Of the patients, 67 were of New York Heart Association (NYHA) functional class III or IV and 15 of the patient were of NYHA II.

Concomitant mitral valve surgery was performed in 82% of the patients and aortic valve surgery in 9% of the patients. Triple valve surgery was performed in 7% of the patients. Only 2% of the patients had tricuspid valve repair as the sole valve procedure. There was no significant difference between the Kay and ring annuloplasty patients in age, sex, NYHA class, preoperative pulmonary artery systolic pressure (PASP), preoperative right ventricular (RV) dysfunction, and concomitant surgical procedures. RV dysfunction was defined as any impairment in RV contraction noted on echocardiography. Left ventricular ejection fraction (EF) was higher in patients undergoing Kay annuloplasty than in those undergoing ring annuloplasty (50 vs. 48%).

Preoperative TR was in four severe out of the 28 patients, three moderate to severe in 26, and two moderate in 28 patients (Table 1). Median TR was of grade 3 (moderate to severe) for both groups.

Table 1: Overall preoperative and surgical characteristics of the patient by annuloplasty type

Characteristic	Overall	Kay annuloplasty		Ring annuloplasty	
Number of patients	82	55	67	27	32.9
Age (years)	52±14	54±14	50±14		
Female sex	52	32	58%	20	74%
Preoperative NYHA					
Class II	15	10	18.5%	5	18.5%
Class III	41	29	52%	12	44.4%
Class IV	26	16	29.5%	10	37.1%
Preoperative TR grade					
+2 (moderate)	28	18	32.7%	10	37%
+3 (moderate to severe)	26	17	30.9%	9	33.3%
+4 (severe)	28	20	36.4%	8	29.7%
Preoperative MR grade NS					
+3	38	21	38.1%	17	63%
+4	54	34	61.9%	10	37%
Preoperative RV dysfunction	29	14	25.4%	11	40.7%
Preoperative LVEF	49±12	50±12		48±13	
Preoperative PASP	52±16	51±17		52±15	
Bypass time (min)	127±43	109±39		145±47	
Cross-clamp time (min)	96±44	88±43		104±45	

LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; PASP, pulmonary artery systolic pressure; RV, right ventricular; TR, tricuspid regurgitation.

Operative techniques

All annuloplasties were performed during concomitant aortic and/or mitral valve surgery with cardioplegic arrest. Ring annuloplasty was performed by standard operative techniques [10,15]. The Kay annuloplasty technique was performed by placing a double pledget-supported mattress suture of 2-0 Ethibond from the anteroposterior commissure to the posteroseptal commissure along the posterior annulus (Figs. 1 and 2).

This double multifilament suture is then tied down over an obturator, such as a 27- or 29-mm valve sizer, which satisfactorily reduces the orifice size without placing undue strain on the annuloplasty repair and obliterates the posterior leaflet.

As we know, the primary anatomic problem in functional TR is anatomic dilation of the posterior tricuspid annulus, because this is the only unsupported area of the tricuspid valve ring, as opposed to the anterior and septal positions [22]. Thus, a posterior annuloplasty should be effective for most cases of functional TR. The entire procedure may be accomplished in less than 10 min and does not produce tricuspid stenosis. In all patients, intraoperative transesophageal echocardiography was performed to confirm elimination of TR.

Follow-up

Follow-up data (vital status, functional status, and/or postoperative echocardiograms) were obtained for 82 patients.

Echocardiographic reports were obtained from the patient's cardiologist. Postoperative echocardiograms were available for 82 patients. Surviving patients were assessed by telephone with questionnaires approved by the institutional review board. The mean follow-up time was 3 years. Functional status and occurrence of subsequent cardiac operations were determined.

Assessment of repair

Preoperative and postoperative transesophageal echocardiographic reports were used to assess TR grade. Interpretation of follow-up echocardiograms was obtained at as many time points as available for each patient.

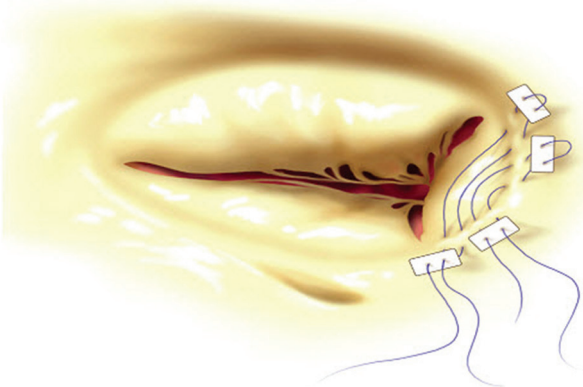


Figure 1: Placement of sutures in tricuspid repair (according to Kay *et al.* [13]).

Median time of echocardiographic assessment was 3 months, 6 months, 1 year, 2 years, and 3 years.

TR was graded as 0 for no regurgitation, 1 for mild, 2 for moderate, 3 for moderate to severe, and 4 for severe, as defined by the American Society of Echocardiography.

Statistical analysis

We use the SPSS 21 (IBM company USA) analytic system. The development of 2 TR was defined as the presence of sustained 2 TR on serial echocardiograms.

To evaluate TR (mean TR and TR grade) over time, we performed repeated measures [23,24].

RESULTS

Cardiopulmonary bypass and aortic cross-clamp times

Patients who underwent Kay annuloplasty with mitral valve procedures had a mean cardiopulmonary bypass time of 109 ± 39 min and aortic cross-clamp time of 88 ± 43 min.

Patients who underwent ring annuloplasty had a mean cardiopulmonary bypass time of 145 ± 47 min and aortic cross-clamp time of 104 ± 45 min, respectively (Table 1).

Cardiopulmonary bypass time and aortic cross-clamp time were shorter, respectively, in the Kay bicuspidization patients.

Mortality, reoperations, and functional improvement

There were no deaths in the Kay bicuspidization annuloplasty group and in the ring annuloplasty group.

In spite of that, the ring group had a lower preoperative EF and higher preoperative TR than the Kay annuloplasty group.

Only six patients underwent reoperative valve surgery during the follow-up period of this study.

Of these, only one patient underwent a reoperative tricuspid valve repair.

NYHA class significantly improved for both groups preoperatively; 45 patients of Kay bicuspidization and 22 patients of ring annuloplasty were of NYHA class III or IV. At follow-up, 15% of Kay bicuspidization and 14% of ring patients remained class III or IV. The mean NYHA class

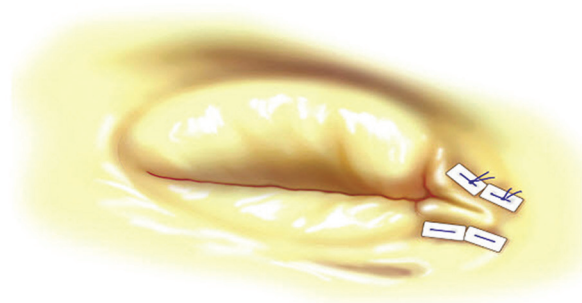


Figure 2: Result of tricuspid repair (Kay bicuspidalization of the tricuspid valve).

improved from 2.6 to 1.4 with Kay bicuspidization and from 2.8 to 1.5 in ring annuloplasty patients.

Efficacy and durability of tricuspid annuloplasty

To evaluate overall efficacy and durability of annuloplasty, we evaluated TR grades by serial echocardiogram.

All annuloplasty types proved efficacious at reducing TR. Mean TR grade decreased by ~40% in both groups from before the operation to the last follow-up. The mean TR grade for each group was grade 3 (moderate to severe) preoperatively and improved to grade 2 (moderate) at last follow-up.

At the end of study, TR in Kay bicuspidization annuloplasty patients was zero to mild in 75%, moderate in 11%, moderate to severe in 6%, and severe in 8%. In ring annuloplasty patients, TR was zero to mild in 69%, moderate in 14%, moderate to severe in 7%, and severe in 10%. There was no statistically significant difference in mean TR grade or prevalence of TR at the end of follow-up between the two groups.

Risk factors for repair failure

Higher preoperative TR was found to be a risk factor for the development of recurrent TR. Higher left ventricular EF demonstrated a trend to be a risk factor for significant recurrent TR. In patients with good left heart function (i.e. good left ventricular EF and lower MR), preoperative TR may indicate a greater degree of valve dysfunction, such as annular dilation or valve tethering, which may be less amenable to repair [25].

Preoperative NYHA class was also not found to be significant factors. There was no statistically significant difference in the prevalence of TR between patients in NYHA class I/II and those in NYHA class III/IV.

Similarly, preoperative PASP and RV dysfunction were not found to be risk factors for recurrent TR.

To evaluate whether there was a correlation between postoperative PASP and tricuspid repair failure, we determined the PASP at the time of failure (from the echocardiographic data) and compared it with patients whose repair did not fail.

Higher postoperative PASP was a significant risk factor for repair failure, regardless of the annuloplasty type. PASP was higher in patients who had unsuccessful annuloplasty than in patients who did not.

To evaluate whether there was a correlation between left heart valve repair failure and tricuspid repair failure, we determined the predicted mean MR over time in patients in whom moderate recurrent TR developed postoperatively.

There was no correlation between tricuspid repair failure and recurrent mitral valve surgery.

DISCUSSION

Many studies have evaluated the long-term outcomes of tricuspid valve annuloplasty. Most of them focus on outcomes such as survival and freedom from reoperation.

Also, the decision to perform an annuloplasty and the type of annuloplasty is often dependent on surgeon opinion and experiences, with little objective data to guide decision making.

Survival itself may be dependent on multiple factors and is not necessarily related to tricuspid annuloplasty. Freedom from reoperation may not take into account many patients who have recurrent TR and they are on medical treatment or not fit for reoperation [8]. Despite logistical and statistical challenges, a better outcome to evaluate is the degree of TR, as this is typically the indication for operation [26].

In this study, we have evaluated TR over time after Kay bicuspidization and ring tricuspid annuloplasty. In our experience, both bicuspidization and ring annuloplasty produce an effective, durable repair at 3 years postoperatively.

Significant 3 or 4 residual TR occurred in 8% of patients early (within 1 month) after operation for all types of annuloplasty.

These results are similar to a previous study performed by McCarthy *et al.* [12]. Their detailed study of 790 patients found that 14% of patients had three or four residual TR early after operation for all annuloplasty types, but ring repairs (Carpentier–Edwards ring) provided a more durable repair than suture annuloplasty over an 8-year period. In McCarthy's study [12], at 3 years postoperatively, three or four TR occurred in ~25% of de Vega patients, 27% of Peri-Guard (Bio-Vascular Inc., St Paul, Minnesota, USA) patients, 15% of the Carpentier–Edwards ring patients, and 18% of the Cosgrove–Edwards band patients.

In this study, 16% of Kay bicuspidization and 18% of ring annuloplasty patients had three or four TR at 3 years postoperatively.

Thus, at 3 years, our outcomes with suture bicuspidization were superior to the de Vega and Peri-Guard annuloplasties and equivalent to ring annuloplasty outcomes presented in the McCarthy study.

Suture annuloplasties, particularly the continuous running type, like the de Vega [14], have been criticized for being unpredictable and unreliable, perhaps owing to the long suture line or the use of polypropylene suture material, which may break and slide through the tissue as the annulus dilates [27].

Bernal *et al.* [20], however, have reported excellent results in 232 patients with the de Vega annuloplasty at 6.8 years postoperatively, with 86% of patients having zero to mild TR. Similar to the Revuelta segmental annuloplasty, the posterior suture bicuspidization technique described in this article is performed with a braided, multifilament suture (2-0 Ethibond) [28]. This suture is less likely to break and thus provides a more durable repair to the area that primarily dilates to produce functional TR. This repair may be performed in less than 10 min.

In this study, we found that cardiopulmonary bypass and aortic cross-clamp times were 17 ± 10 min shorter in the bicuspidization group. Since there were no differences in the number and distribution of concomitant procedures between the two groups, the reduced cardiopulmonary bypass and aortic cross-clamp times were primarily because of the faster tricuspid annuloplasty performed.

Despite 40 years of evolving annuloplasty techniques, there has been no consensus on the management of functional TR. Recent guidelines from the American College of Cardiology and American Heart Association recommend tricuspid annuloplasty during mitral or aortic valve surgery in patients with severe TR [29].

Although most surgeons agree that a patient with severe, symptomatic TR requires repair, many surgeons favor a conservative approach in patients with only moderate TR. The American College of Cardiology/American Heart Association guidelines suggest that functional TR without annular dilation or significant pulmonary hypertension does not require repair [29].

There is a growing body of information, however, that the conservative approach is ineffective and that a substantial number of patients will be left with residual TR, which is associated with increased perioperative and late postoperative morbidity and mortality [6,8,9,30].

In this study, significant grade 3 (moderate to severe) or 4 (severe) early (within 6 months) residual TR developed in 8% of patients and grade 2 or greater TR developed within 3 years in 27% of patients.

There was no correlation between tricuspid repair failure and recurrent mitral valve surgery. Other studies by Matsunaga and Duran [30], Dreyfus *et al.* [31] have also demonstrated a lack of correlation between recurrent MR and recurrent TR after mitral valve surgery.

Although these results are inferior to the outcomes of mitral valve repair, tricuspid annuloplasty was effective in the majority of patients and may be significantly better than the alternative – no repair. Matsunaga and Duran [30] have reported that 53% of patients have grade 2 or greater TR at 3 years after mitral valve repair alone. Matsuyama *et al.* [7] recently reported that 37% of patients with TR grade 2 (moderate) preoperatively have TR grade 3 (moderate to severe) or 4 (severe) at 8 years after mitral valve repair alone.

In this study, 96% of patients had TR grade 2 or greater TR preoperatively.

Thus, the difference between conservative management and tricuspid annuloplasty may be even more pronounced in patients with grade 3 or 4 TR.

Previously, patients with zero to mild TR have demonstrated a significantly lower mortality than patients with moderate-to-severe TR [9]. At 3 years, 73% of patients in

this study had zero to mild TR. Thus, we believe that tricuspid annuloplasty should be performed not only in patients with severe TR, but in all patients with even moderate TR, especially when an effective annuloplasty technique can be performed rapidly and reproducibly. Dreyfus *et al.* [31] even advocate that any patient with substantial annular dilation should undergo repair regardless of the TR grade. We believe that our kay suture bicuspidization is a relatively simple, inexpensive technique that can be performed rapidly and should be used in all patients with at least moderate TR, who present for left-sided valve surgery. In our experience, this technique has been as effective as ring annuloplasty in the midterm postoperative period.

Limitation

We have a lot of limiting factors such as the limited number of cases, echocardiographic experiences differ between doctors, limited time of follow-up, the use of one type of suture annuloplasty, and one type of ring.

CONCLUSION

In summary, we have demonstrated that bicuspidization annuloplasty and ring annuloplasty for functional TR were equally efficacious and durable at reducing TR up to 3 years postoperatively. Sixty-nine percent of ring annuloplasty and 74% of bicuspidization annuloplasty patients remained free from moderate TR in the midterm postoperative period. Risk factors for annuloplasty failure included greater preoperative TR grade, preoperative TR without concomitant MR, and higher postoperative PASP.

Preoperative NYHA class, preoperative PASP, preoperative RV dysfunction, and recurrent MR were not significant risk factors.

Kay bicuspidization annuloplasty is inexpensive, simple to perform, and reduces the operative time. Our experience suggests that bicuspidization annuloplasty is a reliable method for tricuspid annuloplasty and should be given consideration when approaching every patient with functional TR undergoing mitral valve surgery.

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Conflicts of interest

There are no conflicts of interest.

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